Space Weather Technical Forecast

Issued on Thursday, 20 July 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Ongoing (S1) Solar Radiation Storm day 1 (20th). Minor/Moderate R1/R2 Blackouts likely throughout. Chance of G1/G2 (Minor/Moderate Storms) 20th and 21st.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate, with two M-class flares observed, both from AR3363, with a peak M3.8 at 19/1725 UTC. This region rotated round the southwest limb to the far side early in the period. There are currently nine sunspot regions on the visible disc. The largest regions are currently AR3372 (Fho/Beta-Gamma) and AR3373 (Eki/Beta-Gamma), however both of these regions have remained relatively stable with perhaps a reduction in complexity through the period. AR3376 in the northeast has shown some Common-class activity. It is complicated by the fact it is magnetically aligned north-south, but has also shown some simplification recently with the loss of its delta spot. A large region continues to emerge around the northeast limb, it has been numbered AR3379 and is currently classed Eho/Beta, although this may change as it rotates further into view. All other regions on the disc remain small or simple with little change.
A CME was observed leaving the west limb of the Sun in association with the M3.8 flare. It is currently being modelled but is thought unlikely to be Earth directed. No other Earth directed CMEs were observed in the available imagery.

Solar Wind / Geomagnetic Activity: The solar wind parameters are indicative of a gradual return to a slow regime. The solar wind slowly declined from around 480 to 400km/s, with average or below average density (1-7 ppcc). The total magnetic field (IMF), Bt, has been weak and below 6nT. The north-south component fluctuated between +4 and -3nT but was mostly orientated northward. Phi angle was consistently negative (towards the Sun). This resulted in Quiet geomagnetic activity (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy (greater than 2MeV) electron flux remained largely at Moderate levels, with a peak of 1140pfu observed at 19/1845 UTC. The 24-hour integrated fluence responded with a corresponding increase but remained well below the Active (1e8 integrated pfu) threshold. A fluence of 5.47e7 pfu was recorded at 20/0000 UTC. The high energy proton flux (greater than 10MeV), as observed by GOES16, is displaying a slight declining trend but remained just above the Minor (S1) Storm threshold following the M5.7 flare that occurred 18/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to be Moderate over the following days, with isolated M-class flares likely and a slight chance of an X-class flare.

Solar Wind / Geomagnetic Activity: Two Earth-directed CMEs feature in this forecast, with a glancing blows possible on Day 1 (20th) and another one on Day 2 (21st). However, confidence is very low with regards to the strength and timing of the second CME. Connections with coronal hole high speed streams may become established at times but these are small and most likely to

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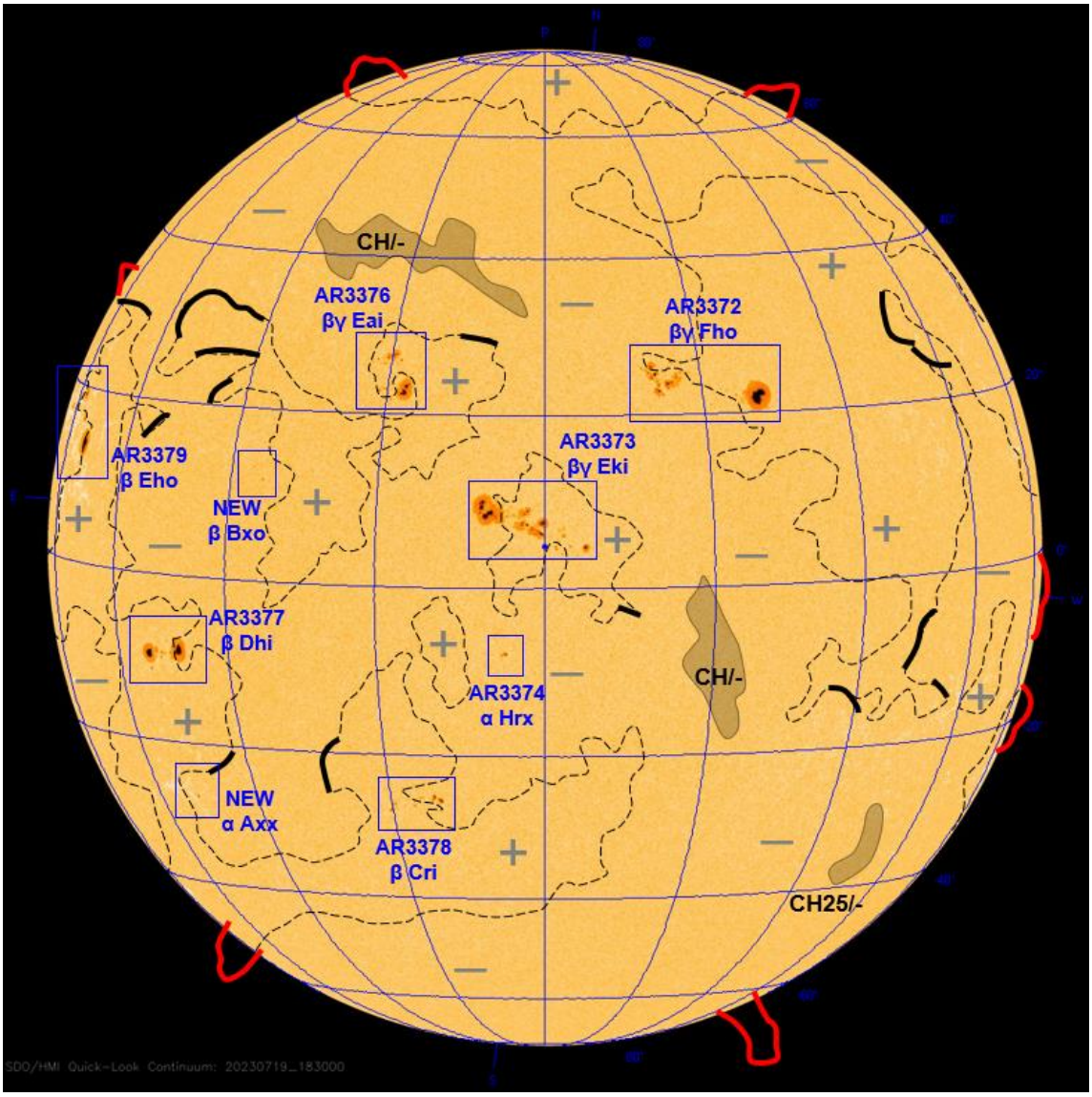
be masked by CME effects. Solar winds are likely to become mostly elevated and perhaps strong at times on Days 1 and 2, before slowly easing on Days 3 and 4.
Quiet geomagnetic activity is likely to become Active on Day 1 (20th) with a chance of G1/G2 (Minor/Moderate) storms intervals into Day 2 (21st). Activity returning to mainly Quiet with a chance of Unsettled intervals through Day 3 (22nd), as CME effects wane.

Energetic Particles / Solar Radiation: The high energy electron flux (greater than 2MeV) is expected to become suppressed during Days 1 and 2 due to the possible arrival of 2 CMEs. An increase is likely thereafter, with a chance of High levels and an exceedance of electron fluence Active threshold (1e8 integrated pfu). The current ongoing minor (S1) solar radiation storm will likely to continue to decline if no further significant proton rich flares are emitted, dropping below the S1 threshold on day 1 (20th).

Figure 1. Solar Analysis Valid 19/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Two Earth-directed CMEs feature in this forecast. The first one originates from the M5.7 flare that occurred around 18/0000 UTC. While the bulk of the ejecta is expected to pass the South and West of Earth, it may give a glancing blow during the UTC morning of the 20th (Day 1). The second one was observed leaving the Sun from the northeast limb around the same time as the M2.1 flare that occurred around 18/2000UTC. While the bulk of the ejecta is believed to head east of the Sun-Earth line, it may give a glancing blow on Day 2 (21st). However satellite imagery was very scarce during the eruption, giving low confidence in the analysis.
Otherwise, solar winds are currently close to ambient levels. Winds may become slightly elevated at times due to coronal hole high speed stream influences, but these are likely to be weak with only minor geomagnetic impacts.
Quiet geomagnetic activity is likely to become Active on day 1 (20th) with a chance of G1/G2 (Minor/Moderate) storms intervals into day 2 (21st). Activity returning to mainly Quiet with a chance of Unsettled intervals through day 3 (22nd), as CME effects wane.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	30	10	1
Strong	G3	No	10	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0145 UTC	Asymmetric Full	M5.7 from AR3363	SW quadrant	1630 km/s	20/0600 UTC +/- 6 hrs	Bulk of ejecta passing S and E of Earth
18/2300 UTC	Asymmetric Full	M2.1 from AR3376	NE quadrant	1200 km/s	21/0900 UTC +/- 6 hrs	Bulk of ejecta passing W of Earth

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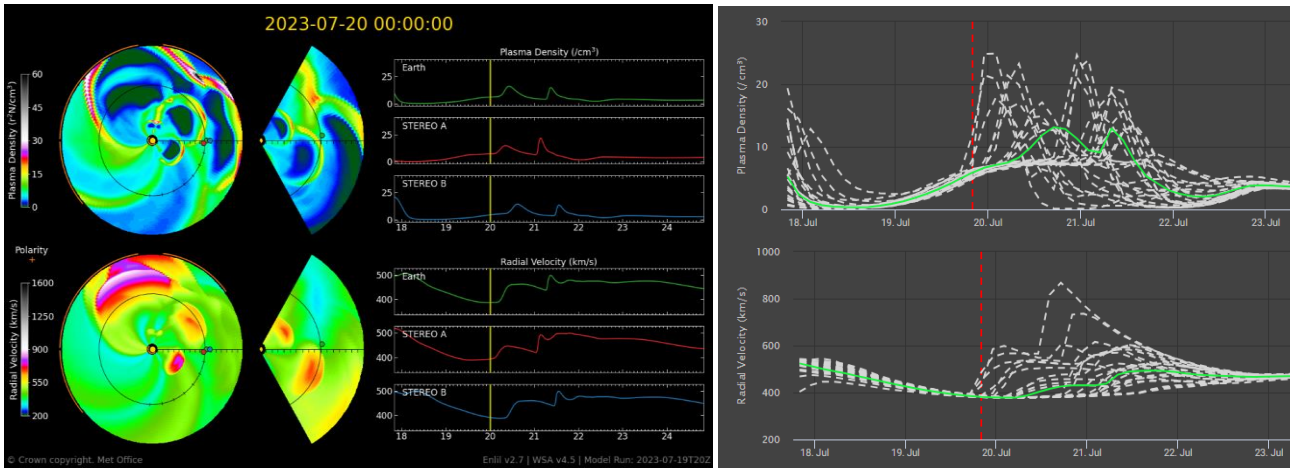
Figure 2: MOSWOC Enlil and Ensemble, showing possible CME arrivals 20th and 21st.



Radio Blackouts - X-Ray Flares:

Solar activity has been was Moderate, with several M-class flares observed. The largest one was a M3.8 flare peaking at 19/1725 UTC, which occurred from the southwest limb and probably the departing EX3363.
There are currently up to nine sunspot regions remaining on the visible disc, since the departure of the large and complex region (EX3363) to the far side. The largest regions are currently AR3372 (Fho/Beta-Gamma) and AR3373 (Eki/Beta-Gamma), however both of these regions have remained relatively stable over the past 24 hours. AR3377 (Dhi/Beta) in the southeast has shown some growth, but is also remains stable. AR3376 (Eai/Beta-Gamma), in the northeast, has shown some minor activity. It is complicated by the fact it is magnetically aligned north-south, but has shown some simplification with the loss of its delta spot. A large region continues to emerge around the northeast limb, it has been numbered AR3379 and is currently classed Eho/Beta. All other regions on the disc remain small or simple with little change.

Activity is likely to remain Moderate over the following days, with isolated M-class flares likely and a slight chance of an X-class flare. However, this risk may increase slightly if AR3379 reveals more complexity as it rotates further into view.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

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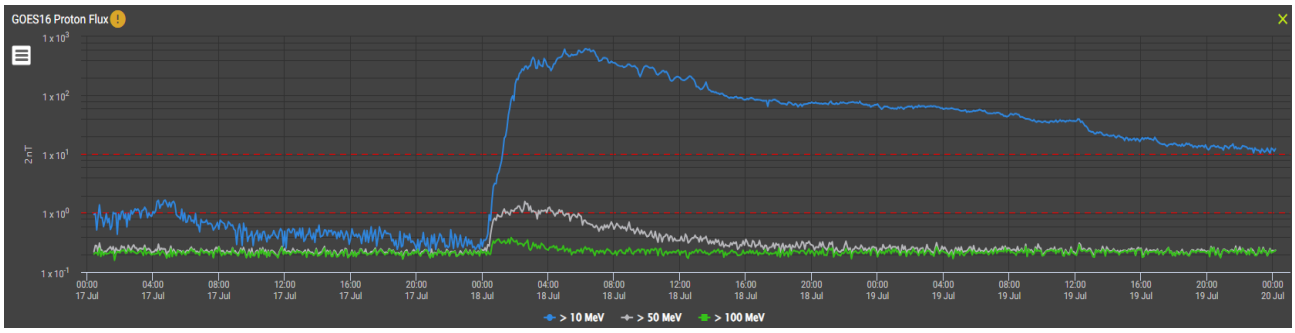
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently above the minor storm (S1) threshold level. Minus any further input the proton flux is forecast to continue to decline and is likely to drop below the S1 level on day 1 (20th). However, the region responsible for this storm, AR3363, is still able to produce Earth effecting solar storms for at least another 24 hours, having only recently rotated onto the far side. Further solar radiation storms are also possible as some of the largest and active regions on the current Earth facing disc, namely AR3373 and AR3376, transit across the western hemisphere over the coming days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	90	40	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: GOES-16 proton flux for previous 3 days



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been largely at Moderate levels in the past 24 hours following the CME that arrived on the 16th, the associated magnetic cloud progressively charging the radiation belts. Increased geomagnetic activity associated with the potential CME arrivals on days 1 and (20th and 21st) is likely to reduce the electron flux initially. However, the denser and stronger winds associated thereafter are likely to replenish the radiation belts on days 3 and 4 (22nd and 23rd), leading the fluence to potentially breach the Active threshold (1e8 integrated pfu).
Low confidence in the timing though. The latest REFM output is in reasonable agreement but it is thought to under-estimate the impacts of the coming CMEs.

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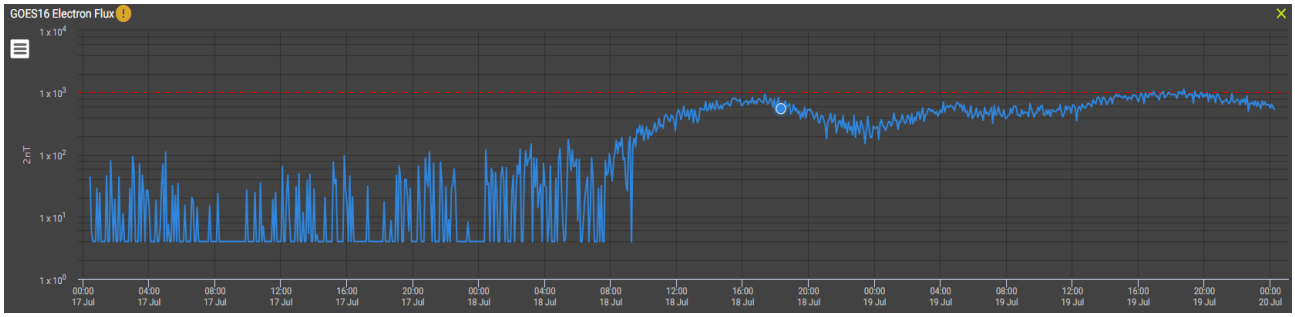
GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	5	40	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	10

Figure 4: GOES-16 electron flux for previous 3 days



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